

LOWER NEMADJI RIVER WATER QUALITY AND MACROINVERTEBRATE COMMUNITY ASSESSMENT, 2015

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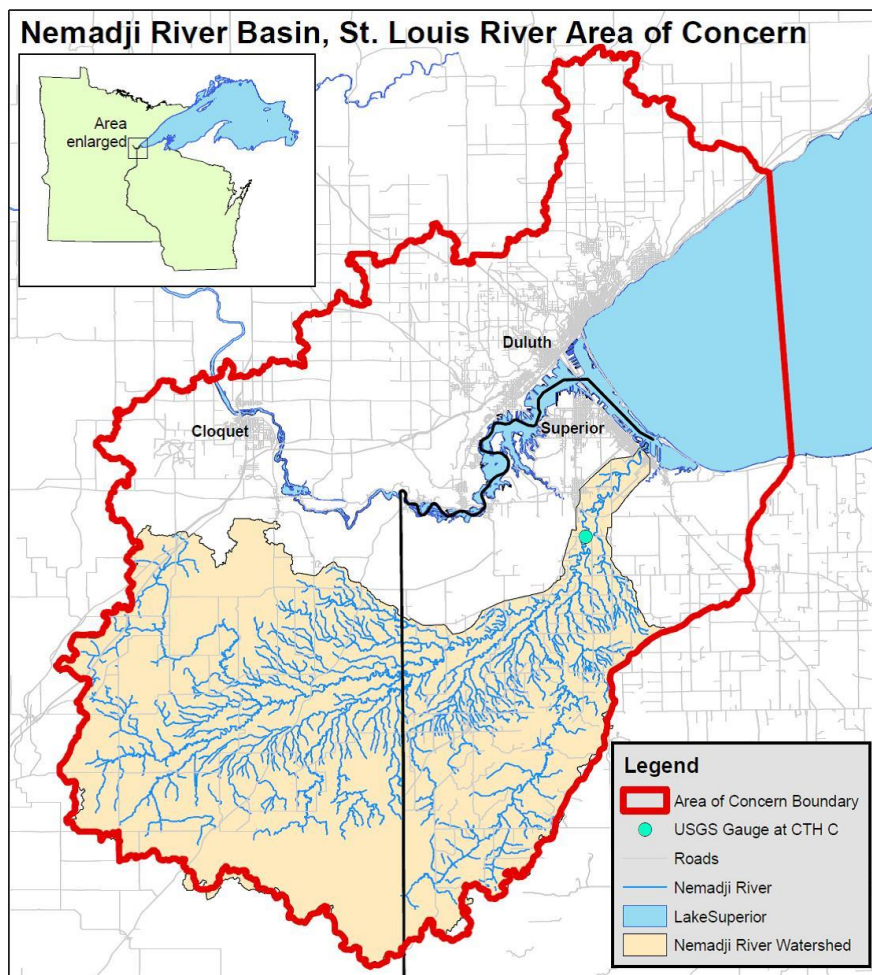
Introduction

The Nemadji River watershed is located in northwest Wisconsin and northeast Minnesota (figure 1). The watershed is included in the St. Louis River Area of Concern (AOC). Both Wisconsin and Minnesota have listed the Nemadji River as an impaired water. Wisconsin added the Nemadji River to the 303d list of impaired waters in 2010. The high sediment load was judged to exceed the narrative water quality standard found in NR 102.4 (a) of the Wisconsin Administrative Code, that states, “Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state.” Other considerations that contributed to the listing decision were:

- Creosote and PAH’s from Crawford Creek are a continuing source of pollutants to the Nemadji River.
- Minnesota has placed the Nemadji River on their 303d list due to exceedences of their turbidity standard (25 ntu), and has begun developing a TMDL to address turbidity. Including the Nemadji River on Wisconsin’s 303d list will allow the two states to work together to develop a comprehensive TMDL that will benefit the entire watershed.
- The median turbidity measured in the Nemadji River at CTH C during 2006-2012 was 27.5 ntu, which exceeds Minnesota’s turbidity standard.

Nemadji River turbidity results from the erosion of clay rich soils in the lower portion of the watershed. The majority of the suspended clay in the river is derived from channel and bank erosion in the river, tributaries, and drainageways. Despite the high turbidity, biological assessments have shown good quality fish and macroinvertebrate communities are present at previous locations monitored (Roesler 2014).

Figure 1.



However, there has been a lack of monitoring in the lower reach of the river in the past. Lake Superior seiche influence, which causes partial backflow in the lower 8.8 miles of the river, has discouraged water quality monitoring. The most downstream water quality data was collected at CTH C, 11.9 miles above the river mouth.

Deep water and lack of coarse substrate has discouraged macroinvertebrate sampling. The most downstream macroinvertebrate sample previously collected was at CTH W, 31.2 miles above the river mouth.

Higher percentages of urban and agricultural land use are present in the lower portion of the watershed. Three intermittent point source outfalls are also present. This suggests poorer water quality and macroinvertebrate communities may be present in the lower river. Monitoring of water quality, and macroinvertebrate sampling were done in 2015 to allow an initial evaluation of conditions in the lower river. Fish community monitoring in 2015 was also done in a separate project (Nelson 2016).

Methods

Water Quality

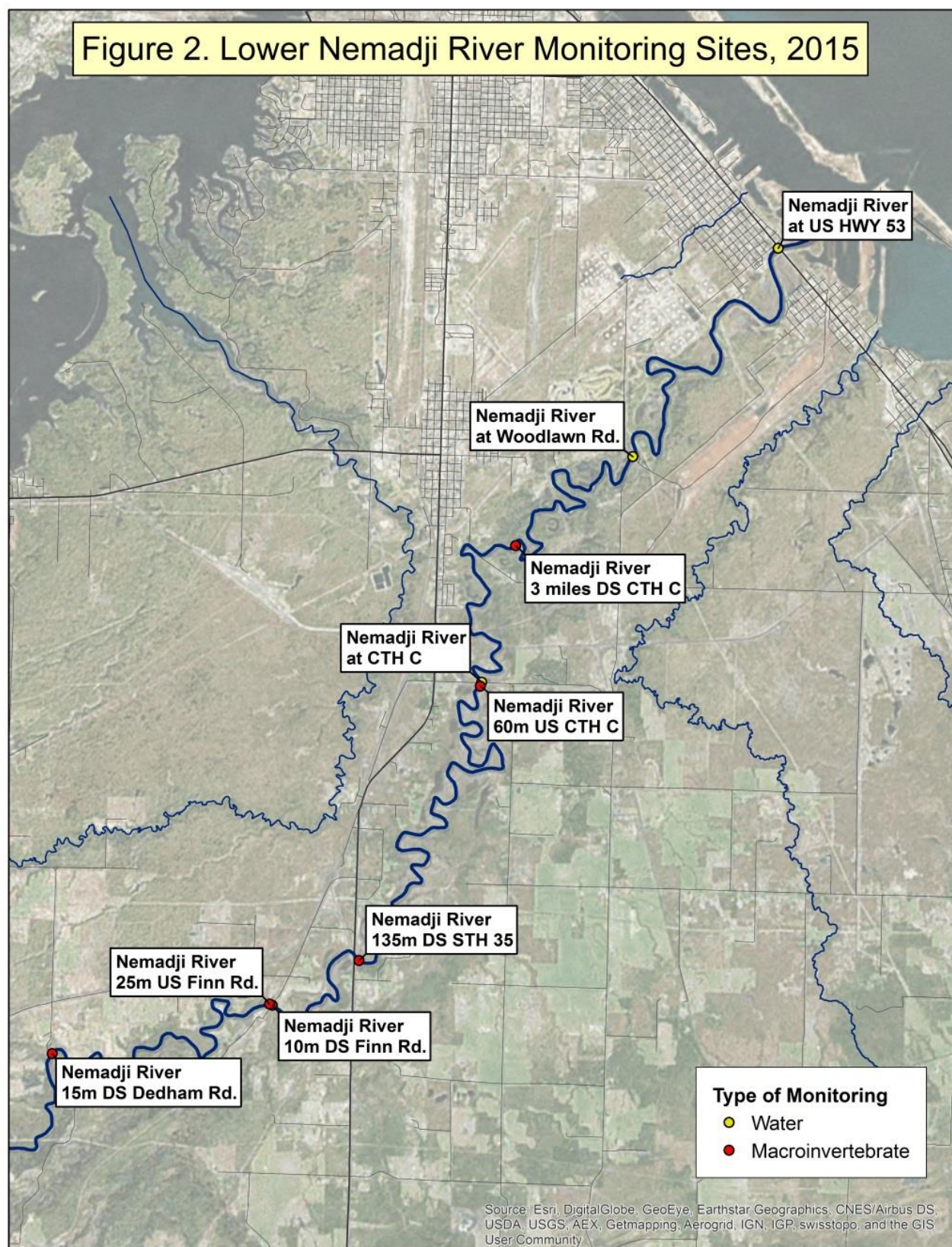
Water quality monitoring was conducted at three sites (fig. 2 and below), monthly from May to October. Monitoring was scheduled for the second Wednesday of each month to provide a systematic random distribution of samples.

Site Description	SWIMS Station No.	Coordinates
Nemadji R. @ CTH C	163003	46.6333, -92.0942
Nemadji R. @ Woodlawn Rd.	10037076	46.6662, -92.0642
Nemadji R. @ USH 2/53	163049	46.6966, -92.0346

Water samples were collected and field parameters were measured following standard DNR protocols. Samples at the two downstream sites were collected with a Kemerrer sampler which was lowered from the bridge near the river center. This was done to avoid any direct influence from backflows caused by Lake Superior seiches. During the periodic backflows, water was observed moving upstream near the stream banks, but continued to move downstream near the stream center.

Water samples were preserved, as needed, and most were shipped on ice to the Wisconsin State Lab of Hygiene for analysis. E. coli samples were delivered on ice to the Lake Superior Research Institute at UW-Superior for analysis so that holding time requirements could be met.

Figure 2. Lower Nemadji River Monitoring Sites, 2015



Field parameters measured were:

- Temperature
- pH
- Dissolved Oxygen
- Conductivity
- Transparency (using a transparency tube)

Lab parameters were:

- Total Phosphorus
- Dissolved Ortho Phosphorus
- Ammonia – N
- Total Kjeldahl N
- Ammonia-N
- Nitrate plus Nitrite – N
- Total Suspended Solids
- Turbidity
- E. coli

Macroinvertebrate Sampling

The six macroinvertebrate sampling sites are shown in figure 2.

Macroinvertebrate communities were assessed by collecting kick samples using a 500 um mesh D-frame net. Due to the lack of riffles and scarcity of coarse substrate (gravel/cobble), all but one sample were collected from woody debris draped with leaf packs and other vegetative debris. One sample, just upstream of Finn Road was collected from cobble substrate to allow a comparison to a sample just downstream of Finn Road collected from woody debris/leaf snags.

Samples were preserved in 85% ethanol and were processed by UW – Superior's Aquatic Biomonitoring Lab. Macroinvertebrates were counted and identified to the lowest possible taxa. Biotic indices and other statistics were generated.

Results and Discussion

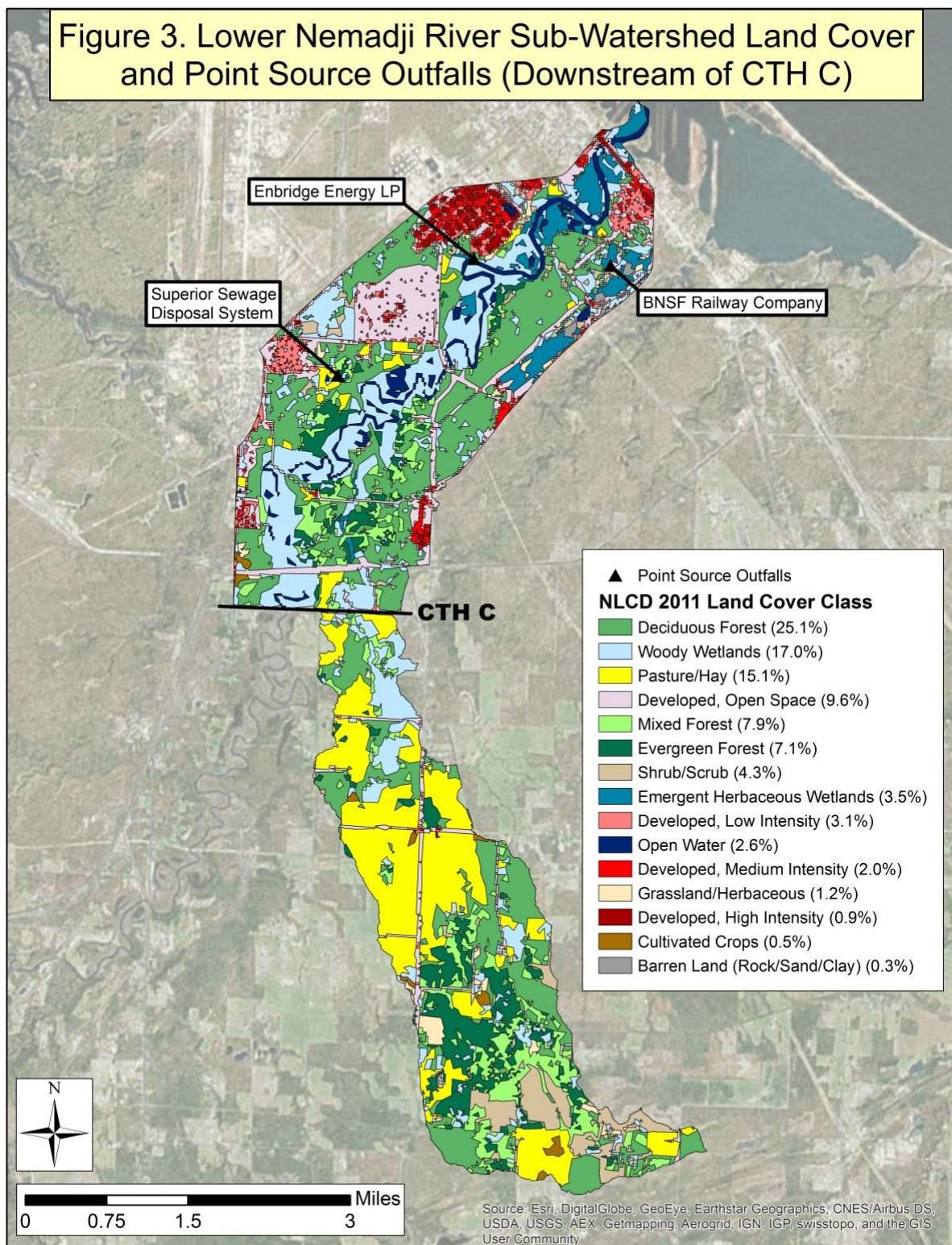
Sub-watershed characteristics

Land Cover

The sub-watershed and land cover for the lower Nemadji River is shown in figure 3. This is the drainage area that contributes water to the river downstream of CTH C. The three point source outfalls in the sub-watershed are also shown. The sub-watershed has an area of 16.2 mi², which is only 3.7% of the total Nemadji River watershed.

Undeveloped land covers occupy 69% of the sub-watershed. Developed agricultural land covers occupy 15.6%, with 15.1% being pasture or hay, and only 0.5% being cultivated crops. Developed urban land covers also occupy 15.6%, with most (12.7%) being developed open space, and low intensity development.

The remainder of the watershed for the Nemadji River, upstream of CTH C, has 87.3% undeveloped land covers. Developed agricultural land covers occupy 9.6%, and developed urban land covers occupy 3%.



Point Sources

There are three point source outfalls in the sub-watershed (figure 3):

- Superior Sewage Disposal System; combined sewer treatment plant (CSTP5)
- Enbridge Energy LP
- BNSF Railway Company

The characteristics of the three point sources and their potential influence on the Lower Nemadji River are discussed in the Water Quality section below.

Water Quality

Water Quality Monitoring Results for 2015

Results of water quality monitoring are shown in table 1.

Dissolved oxygen (D.O.) concentrations range from 6.3 to 11.5 mg/l. All values exceed the 5 mg/l water quality standard for fish and aquatic life.

Conductivity ranges from 93 to 275 umhos/cm. Conductivity tends to be lower when flows are higher since the surface runoff contributing to the high flows tends to have lower conductivity. Transparency (measured with a transparency tube) ranges from 3 to 65 cm. Lowest transparencies occur during highest flows. Erosion of clay from stream and drainageway channels is greatest during high flows. A transparency of 104 cm was measured at the CTH C site during macroinvertebrate sampling on October 22nd, following an extended period of dry weather.

Total phosphorus (TP) concentrations are low to high, ranging from 33 to 501 ug/l. TP concentrations are highest when flows are highest due to watershed runoff and channel scouring. Median TP concentrations at the three sites (49 – 56.3 ug/l) were below Wisconsin's stream water quality standard of 75 ug/l. The upper 90% confidence limit of the median ranged from 133.5 – 159 ug/l. Wisconsin DNR 2016 WisCALM guidance indicates these sites “may meet” the 75 ug/l standard since the median is below, but the 90% upper confidence limit is above the standard.

Dissolved ortho phosphorus (DOP) concentrations are low, ranging from <1.7 – 13 ug/l. The percent of TP as DOP ranges from 2.2 – 25%. There is a tendency for DOP to comprise a smaller percentage of TP when flows are higher, and more particulate bound TP is present.

Total Kjeldahl nitrogen (TKN) concentrations are moderate, ranging from 0.56 to 1.62 mg/l. TKN concentrations are higher when flows are higher due to watershed runoff. Ammonium-nitrogen (NH₄-N) and Nitrate plus nitrite-nitrogen (NO₃₊₂-N) concentrations are very low. NH₄-N concentrations range from <0.0150 – 0.0303 mg/l. NO₃₊₂-N concentrations range from <0.0190 – 0.0868 mg/l.

Table 1.

LOWER NEMADJI RIVER WATER QUALITY DATA, 2015														(Sites listed from upstream to downstream)	
Nemadji River at CTH C (163003)															
	Temp.	D.O.	pH	Conductivity	Transp.	Total P	Diss. ortho P	TKN	NH ₄ -N	NO ₃₊₂ -N	TSS	Turbidity	E. coli	Mean daily flow	
Date	(°C)	(mg/l)	(s.u.)	(umhos/cm)	(cm)	(ug/l)	(ug/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(n.t.u.)	(cfu/100ml)	(cfs)	
05/12/2015	6.5	11.3	6.9	147	5	350	8	1.42	0.03	0.0868	344	374	980	1,490	
06/10/2015	19.9	8.6	6.9	149	29	53	4	0.751	0.0154	0.037	30.7	26.3	35.9	265	
07/08/2015	18.2	8.1	7	93	10	161	10	1.37	0.0243	<0.0190	130	121	648.8	1,580	
08/06/2015	19.5	8.2	6.8	275	54	33	2	0.584	<0.0150	<0.0190	6.2	6.98	57.6	50	
09/09/2015	19.1	8.4	7.8	194	32	54	7	0.72	0.0193	0.0411	24.8	23.5	81.6	140	
10/14/2015	9.1	10.6	7.7	182	65	36/35	8/7	0.638/0.653	<.0150/<.0150	<.0190/<.0190	6.0/6.2	9.73/10.7	22.8/37.3	132	
median	18.7	8.5	7.0	165.5	30.5	53.5	7.3	0.736	0.0174	0.0233	27.8	24.9	69.6	202.5	
Nemadji River at Woodlawn Rd. (10037076)															
	Temp.	D.O.	pH	Conductivity	Transp.	Total P	Diss. ortho P	TKN	NH ₄ -N	NO ₃₊₂ -N	TSS	Turbidity	E. coli		
Date	(°C)	(mg/l)	(s.u.)	(umhos/cm)	(cm)	(ug/l)	(ug/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(n.t.u.)	(cfu/100ml)		
05/12/2015	6.7	11.5	6.8	162	4	436	11	1.62	0.0272	0.0823	346	520	980		
06/10/2015	19.9	8.4	6.7	153	31	49	5	0.753	0.0189	0.0368	17.4	28.3	20		
07/08/2015	18.6	8	6.8	97	8	186	12	1.41	0.0236	<0.0190	161	142	980.4		
08/06/2015	21	7.6	6.7	267	60	33	<1.7	0.698	<0.0150	<0.0190	7	6.47	24.6		
09/09/2015	20.7	7.4	7.7	209	30	49	7	0.738	0.0161	0.047	11.8	22.2	83.6		
10/14/2015	10.5	9.5	7.6	202	52	34/33	6/6	0.557/0.557	<.0150/<.0150	<.0190/<.0190	5.8/6.2	11.6/12.2	24.3/27.5		
median	19.3	8.2	6.8	182.0	30.5	49	6.5	0.746	0.0175	0.0232	14.6	25.3	54.8		
Nemadji River at USH 2/53 (163049)															
	Temp.	D.O.	pH	Conductivity	Transp.	Total P	Diss. ortho P	TKN	NH ₄ -N	NO ₃₊₂ -N	TSS	Turbidity	E. coli		
Date	(°C)	(mg/l)	(s.u.)	(umhos/cm)	(cm)	(ug/l)	(ug/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(n.t.u.)	(cfu/100ml)		
05/12/2015	6.7	11.5	6.6	186	3	501	11	1.51	0.0296	0.0866	392	729	1120		
06/10/2015	19.8	8.2	6.9	173	30	46	4	0.732	0.021	0.0337	15.2	26.6	37.3		
07/08/2015	18.4	7.5	6.8	101	9	164	13	1.3	0.029	0.022	106	138	866.4		
08/06/2015	21.5	7.1	6.9	240	47	43	2	0.736	0.0191	0.0407	10.4	7.1	9.7		
09/09/2015	21.4	6.3	7.5	229	29	69	10	0.85	0.0303	0.0461	10.2	27.2	98.7		
10/14/2015	11.6	8.5	7.6	225	62	35/37	9/9	0.532/0.571	<.0150/<.0150	<.0190/.0200	5.8/5.8	10.9/10.9	15.6/8.6		
median	19.1	7.9	6.9	206	30	57.5	9.5	0.793	0.0293	0.0372	12.8	26.9	68.0		

Total suspended solids (TSS) concentrations and turbidity are moderate to high. TSS concentrations range from 5.8 – 393 mg/l. Turbidities range from 7.1 – 729 ntu. Both parameters are much higher during high flows due to watershed runoff and channel erosion of clay.

Minnesota has a stream turbidity standard of 25 ntu's, which Wisconsin is using as one reason for designating the Nemadji River as an impaired stream. Median turbidities at the three sites are very close to the 25 ntu standard, ranging from 24.9 to 26.9 ntu's (table 1).

E. coli concentrations are low to high, ranging from 9.7 to 1,120 cfu/100ml. Concentrations are much higher during high flows due mostly to watershed runoff. Wisconsin does not currently have an E. coli standard from streams, but it does apply EPA E. coli standards to swimming beaches. An “advisory” standard of 235 cfu/100ml results in a caution sign being placed at a beach to warn of an increased risk of exposure to fecal bacteria and viruses. A “closure”

standard of 1,000 cfu/100ml results in beach closure. Only the two dates with flows >1,000 cfs (May 12th and July 8th) have E. coli concentrations > 235 cfu/100ml. The samples collected on May 12th had concentrations very close to the “closure” standard (980,980, 1,120 cfu/100ml).

Potential Influences on Water Quality Differences at the Three Monitoring Sites

A substantial amount of water quality data from other sources is available for the Nemadji River at CTH C. A USGS gaging station is also operated at that location. No previous water quality data was available for the two downstream sites, Woodlawn Road and USH 2/53. Monitoring the two downstream sites simultaneously with the CTH C site was intended to allow an initial comparison between the sites, and provide some sense of additional inputs to the Nemadji River not being measured at the CTH C site.

There are multiple potential sources of influence on water quality in the Lower Nemadji River that need to be considered. These include the Lake Superior seiche effect, runoff from the Lower Nemadji River sub-watershed, Crawford Creek inflow, and point source discharges.

Lake Superior Seiche Effect

Lake Superior seiches cause backflows up the Nemadji River for about 8.8 miles upstream. The distance the backflows move upstream was determined by observing the lack of, or presence of, vegetative debris snagged on submerged wood during the Fall. Where backflow pulses occurred regularly, wood was free of vegetative debris. Beyond the extent of backflows, flow is unidirectional (downstream) and vegetative debris was retained on wood.

During the periodic backflows, water is observed moving upstream near the stream banks, but continues to move downstream near the stream center. The backflows have the effect of providing another water source to the lower Nemadji River. The water backflowing up the river is derived mostly from the St. Louis River Estuary (SLRE), with additional contributions from Lake Superior.

St. Louis River estuary water quality is compared to Lower Nemadji River water quality below:

Parameter	St. Louis River Estuary (median)*	Lower Nemadji River (median)**
Total phosphorus (ug/l)	27.2	53.3
Total nitrogen (ug/l)	912	786
NO _x -N (ug/l)	182	27.9
NH ₄ -N (ug/l)	35.2	21.4
Total suspended solids (mg/l)	9.9	18.4

*average of May-October 2012 and 2013 medians for St. Louis River estuary harbor zone (downstream of USH 2), in Bellinger 2015

**average of May-October 2015 medians from the three sites on the Lower Nemadji River

The Superior entrance to Superior Bay is in close proximity to the mouth of the Nemadji River (0.6 miles). This makes it uncertain how adequately SLRE water quality represents backflow water, since Lake Superior water may be a larger component of SLRE water in that area.

The SLRE has lower TP and TSS concentrations, roughly similar TN and $\text{NH}_4\text{-N}$ concentrations, and higher $\text{NO}_{3+2}\text{-N}$ concentrations. Backflow of SLRE water into the lower Nemadji River would be expected to contribute to lower TP and TSS concentrations, and higher $\text{NO}_{3+2}\text{-N}$ concentrations.

Conductivity, temperature and dissolved oxygen (D.O.) data for the SLRE is available from the Barker's Island continuous monitoring station operated by the Lake Superior National Estuarine Research Reserve System (NERR). If this data is representative of backflow water, it indicates backflows are contributing to Nemadji River water quality for all of these three parameters:

- Conductivity was higher in the SLRE than in the Nemadji River on five of six dates and so may have contributed to conductivity increases between CTH C and USH 2/53 on those five dates. On the sixth date (August 6th), SLRE water was lower in conductivity and so may have contributed to the decline in the Nemadji River.
- Temperature was higher in the SLRE than in the Nemadji River on five of six dates and so may have contributed to temperature increases between CTH C and USH 2/53 on those five dates. On the sixth date (June 10th), SLRE water was lower in temperature and so may have contributed to the slight temperature drop in the Nemadji River.
- On four of five dates when Nemadji River D.O. declined between CTH C and USH 2/53, D.O. was lower in the SLRE than in the Nemadji River and so may have contributed to the declines.

Lower Nemadji River Sub-watershed runoff

Some sense of possible total phosphorus contributions from the lower Nemadji River sub-watershed runoff can be obtained as follows:

- The sub-watershed is 3.7% of the total watershed.
- Developed land covers are 18.6% higher in the sub-watershed than in the remaining watershed upstream of CTH C.
- Developed land covers can be roughly assumed to export 0.7 kg/ha/yr of TP and undeveloped land covers can be assumed to export 0.1 kg/ha/yr of TP. The weighted average TP export rate for the upper watershed would then be 0.18 kg/ha/yr. Developed land cover TP export in the lower sub-watershed (0.7 kg/ha/yr) is 3.9 times higher than the weighted average for the upper watershed.
- The increase in TP loading to the Nemadji River from the lower sub-watershed would then be - $3.7\% \times 18.6\% \times 3.9 = 2.7\%$ increase.

This suggests that increased concentrations or loads of total phosphorus from sub-watershed runoff would be less than 3%.

Increased concentrations or loads of nitrogen and TSS due to runoff from the lower Nemadji River sub-watershed are also likely to be small. However, nitrogen concentrations or loads are typically poorly correlated with land cover. TSS concentrations or loads in the Nemadji River have been shown to be mostly derived from channel and drainageway erosion and so are unlikely to be predictable from land cover.

Crawford Creek

Crawford Creek flows into the Nemadji River between CTH C and Woodlawn Road. Its watershed is about half the area of the Lower Nemadji River sub-watershed, and about 1.8% of the total Nemadji River watershed. Crawford Creek is contaminated with creosote and PAH's from a former wood preserving facility. Crawford Creek conductivities at Hammond Road during 2009-10 had a median of 316.5 umhos/cm. This is higher than the Nemadji River (166 umhos/cm at CTH C) and so would be expected to cause a slight increase in downstream Nemadji River conductivities.

Point Sources

Superior Sewage Disposal System

The Superior combined sewer treatment plant discharges to the Nemadji River between CTH C and Woodlawn Road (figure 3). The plant only discharges intermittently following heavy rainfalls, when Nemadji River flows are usually high, and so considerable dilution capacity is usually available. During 2015 discharges occurred on 5 days during the May to October Nemadji River monitoring period (July 6,7,8th and September 24,25th).

Discharges can at times have high concentrations of BOD₅ (2-60 mg/l), E. coli (100-250,000cfu/100ml), ammonia (0.2-5.36 mg/l), total phosphorus (40-793 ug/l), and total suspended solids (9-189 mg/l). Maximum reported discharge rate in July was 4.6 cfs. Nemadji River flow on July 8th was 1,580 cfs (table 1).

E. coli increases in the Nemadji River from this point source may be one of the more distinguishable impacts. E. coli concentrations were higher at the two sampling sites downstream of this source than at the upstream sampling site on July 8th (table 1).

BOD₅ concentrations from this point source may contribute to reduced dissolved oxygen concentrations downstream, as was observed on July 8th (table 1). Deposition of oxygen-demanding solids on the stream bottom might contribute to delayed, chronic, oxygen demand.

Enbridge Energy

Enbridge Energy discharges to the Nemadji River between Woodlawn Road and USH 2/53 (figure 3). Enbridge Energy typically has occasional discharges of water used to pressure test

tanks and pipelines. Pressure test water is tested for a range of petroleum related compounds to assure permit limits are met. Pressure test water is treated with carbon filtration prior to release, when necessary.

During 2015 a much larger than usual pipeline pressure test occurred that resulted in discharge of water during most of October. Discharge averaged about 4.6 cfs, with a mean TP concentration of 238 ug/l. The Nemadji sampling site downstream of the discharge point had a 1.5 ug/l higher TP concentration than the upstream sampling site on October 14th (table 1).

Average concentrations of other parameters from the three outfall sites in October were:

- BOD₅, 3 – 8.7 mg/l.
- Ammonia, 0.54 – 1.3 mg/l
- TSS, 5.3 – 16.9 mg/l

These concentrations are unlikely to produce measureable impacts in the Nemadji River. Conductivity of the discharges is not reported, so they are a possible contributor to higher conductivities in the Nemadji River.

BNSF Railway Company

BNSF Railway Company discharges to the Nemadji River between Woodlawn Road and USH 2/53 (figure 3). BNSF Railway Company discharge is mostly taconite storage pile runoff that is treated in a retention/settling pond. Small amounts of maintenance washwater pass through a grit chamber, an oil/water separator, and a concrete lagoon, before also entering the retention/settling pond. Pond discharge was generally continuous during April through October of 2015 and averaged 1.5 cfs. Average concentrations of water quality parameters in past years were:

- TP, 120 ug/l (one sample)
- TSS, 8.9 mg/l
- BOD₅, 2 mg/l
- Chloride, 104 mg/l
- Iron, 0.5 mg/l

With the exception of chloride, this point source appears unlikely to produce measureable impacts to the Nemadji River. Nemadji River samples were not tested for chloride in 2015. Chloride does contribute strongly to conductivity, which was tested. Conductivity was higher at the downstream monitoring site (USH 2/53) than the upstream monitoring site (Woodlawn Rd.) on 5 of the 6 sampling dates.

Water Quality Differences at the Three Monitoring Sites

Water quality parameter differences between the upstream site (CTH C) and the downstream site (USH 2/53) are shown in table 2, below. Some parameters show changes that appear to be significant. The previous discussion on potential influences on water quality identifies some possible explanations for occasional differences. Due to the limited data collected and the complexity of the inputs that occur, further interpretations are difficult or speculative.

Potential influence of backflows on conductivity, temperature, and dissolved oxygen (D.O.) are discussed above (Lake Superior Seiche Effect). Other potential influences on temperature and D.O. include:

- The Nemadji River widens, deepens, and slows between CTH C and USH 2/53. Solar radiation inputs may also be a contributor to the increases.
- Reduced oxygen solubility due to temperature increases may also contribute to the decreases (up to 1 mg/l). Sediment oxygen demand might be higher in the lower river if temporary deposition of organic solids is occurring due to reduced stream velocities. This could also contribute to D.O. decreases.

Total phosphorus increases on five of six dates, but two of the five increases are ≤ 3 ug/l and not significant. Turbidity increases on all six dates, but half of the increases are less than 1 n.t.u. and probably not significant. Transparency decreases on five of six dates, although most decreases are 3 cm. or less and may not be significant.

Table 2.

Unit change and % Change from CTH C to USH 2/53													
	Temp.	Temp.	D.O.	D.O.	pH	pH	Conductivity	Conductivity	Transp.	Transp.	Total P	Total P	Mean daily
	(oC)	(oC)	(mg/l)	(mg/l)	(s.u.)	(s.u.)	(umhos/cm)	(umhos/cm)	(cm)	(cm)	(ug/l)	(ug/l)	flow
Date	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	(cfs)
05/12/2015	0.2	3.1	0.2	1.8	-0.3	-4.3	39	26.5	-2	-40.0	151	43.1	1,490
06/10/2015	-0.1	-0.5	-0.4	-4.7	0	0.0	24	16.1	1	3.4	-7	-13.2	265
07/08/2015	0.2	1.1	-0.6	-7.4	-0.2	-2.9	8	8.6	-1	-10.0	3	1.9	1,580
08/06/2015	2	10.3	-1.1	-13.4	0.1	1.5	-35	-12.7	-7	-13.0	10	30.3	50
09/09/2015	2.3	12.0	-2.1	-25.0	-0.3	-3.8	35	18.0	-3	-9.4	15	27.8	140
10/14/2015	2.5	27.5	-2.1	-19.8	-0.1	-1.3	43	23.6	-3	-4.6	0.5	1.4	132
mean =	1.2	8.9	-1.0	-11.4	-0.1	-1.8	19	13.4	-2.5	-12.3	28.8	15.2	

Table 2 (cont.)

	Dissolved	Dissolved												
	ortho P	ortho P	TKN	TKN	NH4-N	NH4-N	NO3+2-N	NO3+2-N	TSS	TSS	Turbidity	Turbidity	E. coli	E. coli
	(ug/l)	(ug/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(n.t.u.)	(n.t.u.)	(cfu/100ml)	(cfu/100ml)
Date	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.	unit ch.	% ch.
05/12/2015	3.00	37.5	0.090	6.3	-0.0004	-1.3	-0.0002	-0.2	48	14.0	355	94.9	140	14.3
06/10/2015	0	0	-0.019	-2.5	0.0056	36.4	-0.0033	-8.9	-15.5	-50.5	0.3	1.1	1.4	3.9
07/08/2015	3	30	-0.070	-5.1	0.0047	19.3	ND	ND	-24	-18.5	17	14.0	217.6	33.5
08/06/2015	0	0	0.152	26.0	ND	ND	ND	ND	4.2	67.7	0.12	1.7	-47.9	-83.2
09/09/2015	3	42.9	0.130	18.1	0.011	57.0	0.005	12.2	-14.6	-58.9	3.7	15.7	17.1	21.0
10/14/2015	1.5	20	-0.093	-17.2	ND	ND	ND	ND	-0.3	-4.9	0.7	6.7	-17.9	-59.7
mean =	1.8	21.7	0.032	4.3	not calc.	not calc.	not calc.	not calc.	-0.4	-8.5	62.8	22.4	51.7	-11.7

Macroinvertebrate Samples

Initial plans to collect samples at multiple sites downstream of CTH C had to be altered due to flow conditions in that section of the river. A relatively wide and deep channel, and low discharge rates in late summer and early fall resulted in inadequate current velocities (< 0.3 ft/sec) to meet sampling protocols for applying Wisconsin DNR macroinvertebrate biotic indices for streams (>0.5 ft/sec) or rivers (>0.3 ft/sec). Furthermore, the periodic backflows prevented any accumulation of leaf packs or other vegetative debris on the woody debris present that would have provided a suitable sampling substrate.

The most downstream site with suitable flow conditions was 3 miles downstream of CTH C. This site was just upstream of the extent of seiche influence and had leaf packs on woody debris.

Summarized macroinvertebrate sample results are shown in table 2. Very healthy macroinvertebrate communities were found at all six sites. All samples had high macroinvertebrate index of biotic integrity (MIBI) values that are rated as excellent. Hilsenhoff biotic index (HBI) values ranged from good to excellent, indicating oxygen availability is consistently good and little organic pollution is present.

Species richness is fairly high ranging from 19 to 41. Percent EPT individuals is high (40-75%), and percent Chironomidae individuals is low (2-21%), which both also suggest good water quality.

The two Finn Road samples were collected from different substrates for comparison. The downstream sample was collected from leaf packs snagged on woody debris, while the upstream sample was collected from cobble. The cobble had fairly heavy coatings of periphyton and silt. The sample from cobble had a similar MIBI, a poorer HBI, higher species richness, a lower percent EPT, and a higher percent Chironomids. The coatings of periphyton and entrapped silt on the cobble substrate were probably a major reason for these differences.

The high quality of the macroinvertebrate community found is consistent with past findings for the Nemadji River. One of the conclusions of “The Red Clay Project Final Report Summary” (Andrews *et al.* 1979) was that “number of macroinvertebrates per unit area, total number of taxa, diversity, and biomass are not significantly affected by clay turbidity and siltation within the Nemadji River system”.

Table 3. Lower Nemadji River Macroinvertebrate Sample Results

Site	SWIMS station #	Date	Macroinvertebrate Index of Biotic Integrity (MIBI)	MIBI Condition Category	Hilsenhoff Biotic Index (HBI)	HBI Condition Category
Nemadji R. 15 m DS Dedham Rd.	10044435	11/02/2015	8.75	excellent	3.99	Very good
Nemadji R. 25 m US Finn Rd.	163233	10/22/2015	9.04	excellent	4.96	Good
Nemadji R. 10 m DS Finn Rd.	163233	10/22/2015	9.32	excellent	2.78	Excellent
Nemadji R. 135 m DS STH 35	163048	11/02/2015	8.69	excellent	3.85	Very good
Nemadji R. 60 m US CTH C	163003	10/22/2015	11.62	excellent	3.73	Very good
Nemadji R. 3 mi. DS CTH C	10044397	10/22/2015	11.34	excellent	3.61	Very good

Table 3.(cont.) Lower Nemadji River Macroinvertebrate Sample Results				
Site	Species Richness	% EPT* Individuals	% EPT* Genera	% Chironimidae Individuals
Nemadji R. 15 m DS Dedham Rd.	39	60	46	13
Nemadji R. 25 m US Finn Rd.	36	40	41	21
Nemadji R. 10 m DS Finn Rd.	19	75	78	2
Nemadji R. 135 m DS STH 35	41	52	38	15
Nemadji R. 60 m US CTH C	33	69	61	13
Nemadji R. 3 mi. DS CTH C	35	72	58	9
*EPT = ephemeroptera (mayflies), plecoptera (stoneflies), trichoptera (caddisflies) Complete sample result information is available on WI DNR's SWIMS data base.				

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